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inventory

Mammal richness and diversity in Serra do Facão region, Southeastern Goiás state, central Brazil

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Abstract: At least 251 mammal species are recorded for the Brazilan cerrado, which, therefore, is the third richest Brazilian biome. Most mammal surveys in Brazilian cerrado result from studies performed opportunistically and in short time periods. The aims of the present study were (1) provide a checklist for the mammalian fauna based on a five-year sampling in Serra do Facão region, Southeastern Goiás state; (2) compare small non-flying mammals diversity in open and forest areas and (3) compare species diversity before and after the flood caused by a hydroelectric reservoir filling. The data was gathered in 19 sampling periods, from May 2008 to September 2013. We sampled open and forest habitats and captured non-flying small mammals with Sherman and Tomahawk live traps and pitfalls; bats were sampled with mist-nets; large mammals were recorded with camera traps, and by direct observations and track surveys in field. We found 20 species of small non-flying mammals, 10 species of bats and 33 species of larger mammals. Species diversity was greater for forest than open habitats, and was also greater before than after the complete reservoir filling. About 10% of the recorded species are included in the Brazilian official list of threatened species. The total richness represents 25% of all cerrado mammal fauna, highlighting the importance of this area for regional mammal fauna conservation.
Keywords: *cerrado, mammal survey, non-flying mammals, bats, large mammals, hydroelectric reservoir.*

GOMES, L.P., ROCHA, C.R., BRANDÃO, R.A., MARINHO FILHO, J. **Riqueza e diversidade de mamíferos na Região da Serra do Facão, sudeste do estado de Goiás, Brasil central.** Biota Neotropica. 15(4): e0033. http://dx.doi.org/10.1590/1676-0611-BN-2015-0033

Resumo: Há 251 espécies de mamíferos de ocorrência confirmada no cerrado, o terceiro bioma brasileiro em riqueza de espécies. A maioria dos inventários da mastofauna do cerrado é resultado de estudos oportunísticos, com curta duração. Os objetivos do presente estudo foram (1) inventariar a mastofauna durante cinco anos de amostragens na região do Aproveitamento Hidrelétrico da Serra do Facão, no sudeste do estado de Goiás; (2) Comparar a diversidade de pequenos mamíferos em áreas abertas e florestais e (3) comparar a diversidade da mastofauna antes e depois da inundação causada pelo enchimento do reservatório do empreendimento hidrelétrico. A coleta de dados foi realizada em 19 campanhas de amostragem, entre maio de 2008 e setembro de 2013. Os pequenos mamíferos não voadores foram amostrados com armadilhas *Sherman* e *Tomahawk*, e armadilhas de queda; morcegos foram amostrados com redes de neblina; e os mamíferos de maior porte foram amostrados com armadilhas-fotográficas, observações diretas e observações de vestígios. Foram registradas 20 espécies de pequenos mamíferos não-voadores, 10 espécies de morcegos e 33 de mamíferos de maior porte. A diversidade de pequenos mamíferos não voadores foi maior em ambientes florestais que em abertos, e foi também maior antes do que depois do enchimento do reservatório da hidroelétrica. Cerca de 10% das espécies registradas estão incluídas na lista oficial dos mamíferos ameaçados de extinção. O total de espécies representa 25% da fauna de mamíferos do cerrado, o que demonstra a importância da área para conservação da mastofauna regional.
Palavras-chave: *cerrado, inventário, pequenos mamíferos não voadores, morcegos, mamíferos de grande porte, reservatório hidrelétrico.*

Introduction

Currently, 701 species of mammals are known in Brazil (Paglia et al. 2012). The mammal richness reported for the cerrado varies from 227 (Carmignotto et al. 2012) to 251 species (Paglia et al. 2012). About 40% cerrado mammals are bats (Chiroptera), 31% are rodents (Rodentia), and 10% are marsupials (Didelphimorphia) (Paglia et al. 2012). This diversity

places the cerrado biome as the third richest for Brazilian mammals. The number of endemic cerrado mammals varies from 25 to 32 species depending on the authors (Carmignotto et al. 2012, Paglia et al. 2012). The distribution of mammal fauna in cerrado is affected by habitat heterogeneity, being approximately 16% of species exclusive to open areas, and about 29% occur exclusively in forest environments (Marinho-Filho et al. 2002). However, the endemism rate is slightly larger for open areas (56%), highlighting the relevance of both open and forested habitats for cerrado mammals conservation (Marinho-Filho et al. 2002).

The original cerrado covered approximately 2 million km^2. However, about half of its area was already removed by human activities, and the actual deforestation persist at rates varies between 22,000 to 30,000 km^2/year (Klink & Machado 2005). Processes of habitat loss and fragmentation, as well as hunting pressure, are among the main threats to mammalian diversity conservation (Rodrigues et al. 2002, Costa et al. 2005, Trolle et al. 2007). Changes in the environment occur in an accelerated rate, causing loss of irreplaceable habitats at local and regional scale, and even resulting in local extinctions (Whitmore & Sayer 1992, Myers et al. 2000).

In this context, inventories are essential because they provide basic information on biological diversity composition of determined areas and regions, providing arguments and justification for the conservation of remnant areas. However, the majority of fauna surveys on cerrado's mammalian fauna are performed punctually and in short time periods.

Herein we present a mammalian inventory based on five years sampling an area affected by the flooding of the reservoir of Serra do Facão Hydroelectric Plant, in southeastern Goiás state. Other aims of this study are to evaluate differences in richness and diversity for small non-flying mammals between (1) environments (open areas and forests) and (2) sampling periods (before and after the hydroelectric plant construction). We also provide reproductive ecological observations for small non-flying mammals.

Material and Methods

1. Area of study

The study was carried out in Serra do Facão region, southeastern Goiás state (Figure 1). The Serra do Facão region is crossed by São Marcos River, which belongs to Rio de la Plata Basin, the second largest river basin in South America (ANA 2007). In November 2009, a dam on the São Marcos River was built to form the reservoir of the hydroelectric plant of Serra do Facão. This reservoir floods ca. 20,000 ha, encompassing five municipalities in the state of Goiás: Catalão, Campo Alegre de Goiás, Davinópolis, Ipameri, and Cristalina - and the municipality of Paracatu, in the state of Minas Gerais.

In the region the climate is tropical (Köppen Aw), with temperatures between 23 and 24°C and mean annual rainfall between 1600 and 1800 mm, and two well-defined seasons, one hot and rainy (October to Match) and other colder and dry (April to September) (Cardoso et al. 2015). The landscape consists of large tracts of plantation areas and pastures, in which there is a mosaic of remnant patches of native habitats,

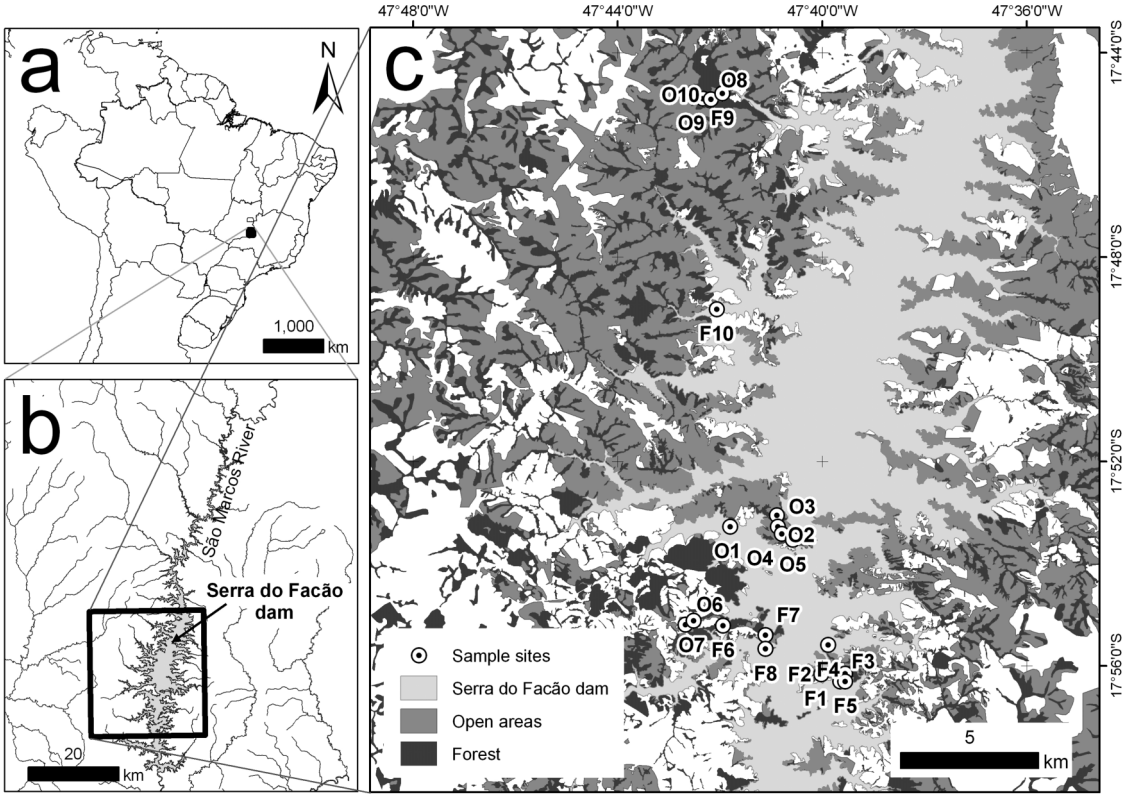

Figure 1. Serra do Facão state of Goiás, and location of sample sites a) Brazil; b) River system in the area; c) Sample Sites. O – Open areas; F – Forest. Description of sampling points and coordinates are on Supplement 1.

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including several open cerrado physiognomies as *campo limpo*, *campo sujo*, *vereda* (palm swamps) , and "cerrado *sensu stricto*", and forest habitats, such as semi-deciduous forest, *mata ciliar* (riparian forest), and gallery forest. Phytophysiognomies were identified according to Oliveira-Filho & Ratter (2002). Grassland without shrubs or trees is called *campo limpo*, and grassland with scattered shrubs and small trees is called *campo sujo*. Open cerrado physiognomies over rock soil and scattered rock outcrops – *cerrado rupestre* (Lenza et al. 2011) was present in some places. The cerrado *sensu stricto* have trees covering more than 30% of canopy, and presents an herbaceous/grassy layer. *Veredas* are valley marshes where the water table reaches the surface and palms *Mauritia flexuosa* are common. Semi-deciduous forest (mesophytic seasonal forest) generally grow on spots of calcareous fertile soils; gallery forests are placed along river banks, and the tree branches cover the water course, forming a "gallery". Riparian forests are also placed along river banks, but the water course is not covered by trees. The sampling sites included both open areas (grassland and "cerrado *sensu stricto*") and forest habitats (gallery forest and semi-deciduous forest).

2. Data Collection

We collected data on 19 field expeditions, with quarterly intervals, from May 2008 to February 2012. In 2013, we done three complementary expeditions in March, June and September. Initially, we gathered data in 10 sampling sites placed in open areas and 10 sampling sites placed in forest habitats (Figure 1, Supplement 1). However, after the impoundment in 2009, three forest sites were flooded. The study was carried out in areas located in the municipalities of Catalão and Campo Alegre de Goiás, state of Goiás (Supplement 1).

We considered small mammals all species of small rodents and marsupials with less than 2 kg (e.g. Bennett 1990, Eisenberg & Redford 1999). This group was sampled using Sherman and Tomahawk traps, and some additional data came from pitfall traps. In every sample sites (Supplement 2), we set up 21 Sherman traps (250 x 80 x 90 mm) and seven Tomahawk traps (300 x 160 x 160 mm), which remained open during three consecutive nights in each field expedition. Traps were placed on soil level and on trees and shrubs, up to 2m high as well, in order to access the greatest number of micro-habitats. Baits consisted of a mixture of peanut butter, banana, canned sardines and cornmeal. All traps were monitored every day at dawn. The sampling effort was 31,496 traps*night.

Pitfall traps consisted by stations composed by four 35-litre plastic buckets arranged in a Y-shaped disposition. All buckets were buried in the ground, placed 4m away from each other, and connected by a plastic fence (0.5m height). Five pitfall trap stations were set at each sample site (Supplement 2). Pitfall traps were kept open for ten consecutive days in each expedition. Although pitfall traps are commonly used for herpetological sampling, they often capture small terrestrial mammals (Mengak & Guynn Jr 1987, Santos Filho et al. 2008), being able to sample species that are rarely captured by more traditional methods (Monteiro-Filho & Graipel 2006, Cáceres et al. 2010). During sampling periods all traps were checked every day and we performed a total sampling effort of 49,600 pitfalls*night.

Bats were recorded only in forest environments (Supplement 2). We used five to ten mist-nets (12 m length x 3 m height) in each sampling site, for a few nights (usually 1-2) per field expedition. The nets were set on forest edges, or inside them, near food sources and shelters, and/or on trails potentially used as flight route. Nets were opened at 18:00 h and closed at midnight. The total bat sampling effort, following Straube & Bianconi (2002), was of 18,144 hours*m^2.

We identified, measured, and weighted all animals captured. We also recorded the reproductive status of all animals. We considered as reproductive all perforated, lactating, or pregnant females. Small non-flying mammals were marked with numbered earrings (National Band & Tags – Mod. 1005 – 1). After data collection, we released all animals at the same place they were captured. Some specimens were collected for further confirmation of identification. All collected animals were deposited in the Mammal Collection of the University of Brasília (Supplement 3). All procedures (capture, handling and marking) followed the guidelines of animal care and use by the American Society of Mammalogists (Sikes & Gannon 2011). All captures and collections were made upon authorization issued by the Brazilian Institute for the Environment (IBAMA ACCTMB No. 198/2010). We used the specific literature for taxonomic identifications (Vizotto & Taddei 1973, Emmons & Feer 1997, Weksler & Bonvicino 2005, Carmignotto & Monfort 2006, Bonvicino et al. 2008, Gardner 2008, Reis et al. 2013). Confirmation of the identifications were done by comparison with material (skins and skulls) housed in the mammal collections of the Zoology Department of the Universidade de Brasília and the Museu Nacional da Universidade Federal do Rio de Janeiro.

We sampled larger mammals opportunistically by tracking them while collecting or setting traps for small mammals sampling. Additionally we set a total of six to ten camera traps (Tigrinus Analog 6.0C), at some sampling site per expedition (Supplement 2). Camera traps were set in open and forest areas, and remained in operation for about ten consecutive days in each expedition. Some were set in trails, others not, but in any case they were set apart at least 1.5 km from each other. In 2013 we changed all camera traps by another digital model (Bushnell Trophy Cam HD). We also took into account direct sights, animals hit by cars and/or carcasses found, as well as indirect observations, such as tracks and feces, obtained during active diurnal and nightly surveys. The total effort performed with camera traps was 14,508 traps*hours. We did not consider photos of the same species taken in less than one hour interval for abundance counting. All species, including carcasses, tracks, and photos were identified using pertinent literature (Becker & Dalponte 1991, Oliveira & Cassaro 1999, Borges & Tomás 2004, Mamede & Alho 2006, Carvalho Jr & Luz 2008, De Angelo et al. 2008).

3. Data Analysis

We used collector's curve based on effort by expedition for checking the reliability of our mammal survey, including all species obtained by all methods. For the analysis of diversity we used the number of individuals and not total captures of small mammals. We used rarefaction curves based on abundance for compare non-flying small mammal diversity between (1) open and forest areas, (2) before and after the reservoir filling in open areas, and (3) before and after flooding in forest habitats. All comparisons were done using Coleman index on EstimateS Version 9.1.0 (Colwell 2013) and tested differences using Z tests (Zar 1999).

Table 1. Mammalian species recorded at Serra do Facão region from 2008 to 2013. Families richness is displayed at parenthesis. Habitat of record and sampling methods are: O = open areas, F = forest, Cap = capture, Vs = visually, Ct = camera trap, Ts = track surveys.

Taxa	Habitat	Sampling method
DIDELPHIMORPHIA		
Didelphidae (8)		
Caluromys lanatus (Olfers, 1818)	F	Cap
Cryptonanus agricolai (Moojen, 1943)	O	Cap
Didelphis albiventris Lund, 1840	O, F	Cap
Gracilinanus agilis (Burmeister, 1854)	O, F	Cap
Micoureus demerarae (Thomas, 1905)	F	Cap
Monodelphis domestica (Wagner, 1842)	O, F	Cap
Monodelphis kunsi Pine, 1975	O, F	Cap
Thylamys karimii (Petter, 1968)	O	Cap
CINGULATA		
Dasypodidae (5)		
Cabassous unicinctus (Linnaeus, 1758)	O	Vs
Dasypus novemcinctus Linnaeus, 1758	F	Ct
Dasypus septemcinctus Linnaeus, 1758	F	Vs
Euphractus sexcinctus (Linnaeus, 1758)	O	Vs
Priodontes maximus (Kerr, 1792)*	F	Ct, Vs, Ts
PILOSA		
Myrmecophagidae (2)		
Myrmecophaga tridactyla Linnaeus, 1758*	F, O	Ct, Ts, Vs
Tamandua tetradactyla (Linnaeus, 1758)	F	Ct, Ts
CHIROPTERA		
Phyllostomidae (10)		
Anoura caudifer (E. Geoffroy, 1818)	F	Cap
Artibeus lituratus (Olfers, 1818)	F	Cap
Carollia perspicillata (Linnaeus, 1758)	F	Cap
Dermanura cinerea (Gervais 1855)	F	Cap
Desmodus rotundus (E. Geoffroy, 1810)	F	Cap
Glossophaga soricina (Pallas, 1766)	F	Cap
Mimon bennettii (Gray, 1838)	F	Cap
Phyllostomus hastatus (Pallas, 1767)	F	Cap
Platyrrhinus lineatus (E. Geoffroy, 1810)	F	Cap
Sturnira lilium (E. Geoffroy, 1810)	F	Cap
PRIMATES		
Atelidae (1)		
Alouatta caraya (Humboldt, 1812)	F	Vs
Callithrichidae (1)		
Callithrix penicillata (E. Geoffroy, 1812)	F	Vs
Cebidae (1)		
Sapajus libidinosus (Spix, 1823)	F	Ct, Vs, Cap
CARNIVORA		
Canidae (3)		
Cerdocyon thous (Linnaeus, 1766)	O	Ct,Vs, Cap
Chrysocyon brachyurus (Illiger, 1815)*	O	Ct, Vs
Lycalopex vetulus (Lund, 1842)*	O	Ct, Vs
Procyonidae (2)		
Nasua nasua (Linnaeus, 1766)	F, O	Ct, Vs, Cap
Procyon cancrivorus (G. Cuvier, 1798)	F, O	Ct, Vs
Mustelidae (4)		
Conepatus semistriatus (Boddaert, 1785)	O	Vs
Eira barbara (Linnaeus, 1758)	F	Ct, Vs
Galictis cuja (Molina, 1782)	O, F	Vs
Lontra longicaudis (Olfers, 1818)	F	Vs, Ts
Felidae (5)		
Leopardus pardalis (Linnaeus, 1758)	F	Ct, Cap, Ts
Leopardus tigrinus (Schreber, 1775)*	F	Ts, Vs

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Table 1. Continued.

Taxa	Habitat	Sampling method
Leopardus wiedii (Schinz, 1821)*	F	Ct
Puma concolor (Linnaeus, 1771)*	F	Ct, Ts
Puma yagouaroundi (E. Geoffroy, 1803)*	F	Vs
PERISSODACTYLA		
Tapiridae (1)		
Tapirus terrestris (Linnaeus, 1758)	F, O	Ts
ARTIODACTYLA		
Tayassuidae (1)		
Pecari tajacu (Linnaeus, 1758)	F	Ct, Vs, Ts
Cervidae (2)		
Mazama americana (Erxleben, 1777)	F	Ct, Vs
Mazama gouazoubira (G. Fischer, 1814)	O, F	Ct, Vs
RODENTIA		
Cricetidae (10)		
Calomys expulsus (Lund, 1841)	O, F	Cap
Calomys tener (Winge, 1887)	O, F	Cap
Cerradomys scotti (Langguth & Bonvicino, 2002)	O, F	Cap
Hylaeamys megacephalus (G. Fischer, 1814)	O, F	Cap
Necromys lasiurus (Lund, 1841)	O	Cap
Oecomys cleberi Locks 1981	F	Cap
Oligoryzomys fornesi (Massoia, 1973)	F	
Oligoryzomys moojeni Weksler & Bonvicino 2005	F	Cap
Oligoryzomys nigripes (Olfers, 1818)	O, F	Cap
Rhipidomys macrurus (Gervais, 1855)	O, F	Cap
Erethizontidae (1)		
Coendou prehensilis (Linnaeus, 1758)	F	Vs
Caviidae (1)		
Hydrochoerus hydrochaeris	F	Ts
Cuniculidae (1)		
Cuniculus paca (Linnaeus, 1766)	F	Ct
Dasyproctidae (1)		
Dasyprocta azarae Lichtenstein, 1823	F	Vs
Echimyidae (2)		
Proechimys roberti Thomas, 1901	F	Cap
Thrichomys apereoides (Lund, 1839)	O	Cap
LAGOMORPHA		
Leporidae (1)		
Sylvilagus brasiliensis (Linnaeus, 1758)	F	Ct, Vs

* Threatened species (MMA 2014).

Reproductive patterns were roughly designed by the percentage of reproductive females in dry and wet seasons. Our sampling of larger mammals with camera traps did not allow the recognition of individuals and abundance estimates. However the number of records may provide an idea of abundance or activity of a given species in the area or specific habitat type.

Results

We recorded 63 species of mammals in the study area: 33 larger mammals, 20 small non-flying mammals and 10 bats (all belonging to the Phyllostomidae family) (Table 1). The collector's curve based on sampling effort by expedition for all species stabilized on the 13th expedition (Figure 2), indicating we performed an adequate effort to sample the local richness. We recorded eight species considered as threatened with extinction (MMA 2014), such as *Puma concolor* and *Priodontes maximus* (Table 1).

The sampling effort with camera traps was equivalent to 14,508 traps*hour, which yielded 231 records of 22 species of large mammals. Photographic records of some species are presented on Supplement 4. Data from direct and indirect observations resulted in 11 additional species that were not recorded by camera traps, totaling 33 species of large mammals observed with all thechniques combined. The most speciose large mammals families were Dasypodidae (n = 5) and Felidae (n = 5). More than half large species (51%) were recorded exclusively in forest environments, 24.5% were recorded only in open areas and 24.5% in both environments. The species with greater number of records were *Mymercophaga tridactyla* (n = 54) and *Sylvilagus brasiliensis* (n = 30). The smallest number of records were obtained for *Lycalopex vetulus* (n = 4) and *Mazama americana* (n = 2).

The sampling effort of 18,144 hour*m^2 with mist nets in forest habitats resulted in capture of 107 individuals of 10 species of bats. The most frequently captured bat species were *Carollia perspicillata* (n = 26) and *Artibeus lituratus* (19), and

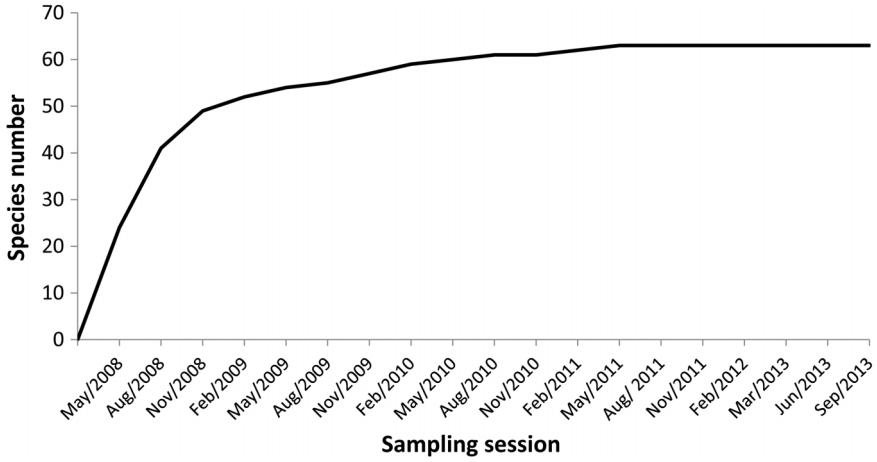

Figure 2. Species accumulation curve (collector's curve) based on effort for all mammalian species recorded in the Serra do Facão hydroelectric plant from May 2008 to September 2013.

Mimon benetti was recorded only once. For small non-flying mammals, the capture success with live traps (Sherman and Tomahawk) was approximately 2%, with 20 species recorded. Pitfall traps did not resulted in exclusive additional records of species. However, two species of rodents (*O. cleberi* and *P. roberti*), and two species of marsupials (*C. lanatus* and *M. demararae*) were recorded exclusively with live traps.

The Cricetidae family was the most representative, with 10 species, followed by Didelphidae (n = 8). Five species were captured only in forest environments, three of them were restricted to open areas, and eleven were captured in both environments. *Gracilinanus agilis* was the most frequently captured small mammal (N = 255), followed by *Calomys tener* (N = 200). These two species were more abundant in dry season (*C. tener* – n = 141 e *G. agilis* – n = 209). Marsupials were reproductive during wet season, whereas rodents were reproductive during all year (Figure 3). About 24% of all *G. agilis* females captured on wet season were reproductive, whereas only 4% of them were reproductive during all dry season. The species *C. tener* was found reproductive throughout the year (Figure 3). The rodents *Oecomys cleberi*, *Proechymys roberti*, and *Rhipidomys macrurus* and the marsupials *Caluromys lanatus* and *Thylamys karimii* were the rarest small mammal species, with only one to three records each. Since field expeditions, we used this group to assess local populational and diversity parameters.

Forest habitats were more diverse in small terrestrial mammals than open areas ($Z = -8.115$; $p < 0.001$; Figure 4). The diversity was higher before flooding for both open ($Z = -8.956$; $p < 0.001$; Figure 5) and forest habitats ($Z = -2.530$; $p = 0.005$; Figure 6)

Discussion

We found mammal richness similar to those reported in long sampling period studies conducted in cerrado Protected Areas (Table 2). Despite our larger sampling effort, we recorded 73% of mammals recorded for Emas National Park,

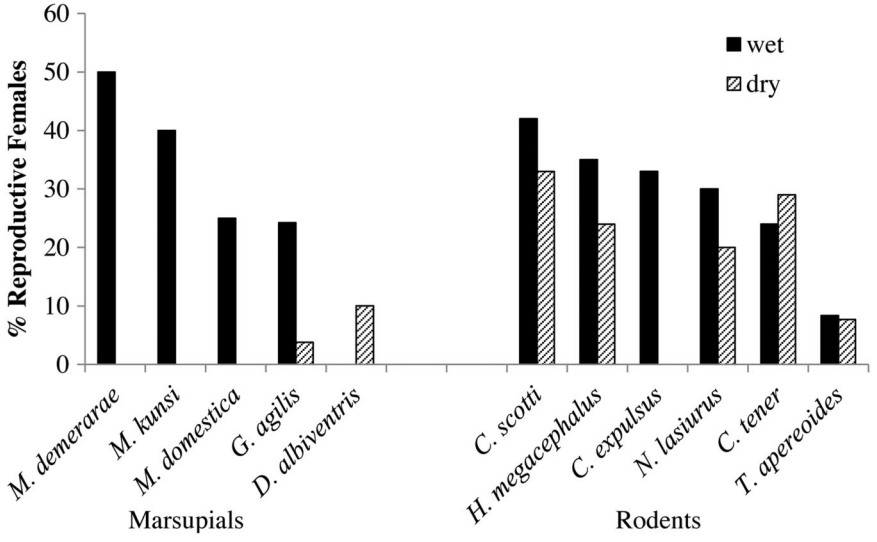

Figure 3. Percentage of reproductive females of marsupials and rodents captured during dry and wet seasons at Serra do Facão region, Goiás state, from May 2008 to September 2013.

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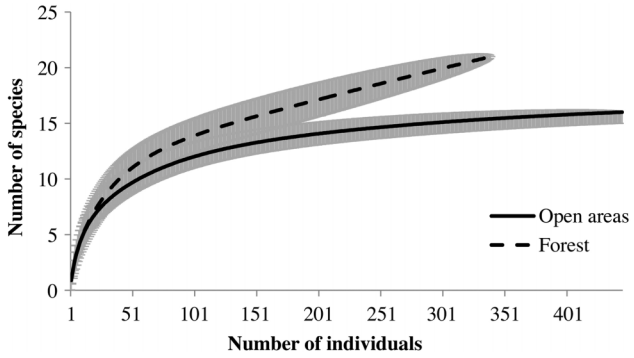

Figure 4. Rarefaction curves (Cole estimator) for small non-volant mammals captured in open and forest environments at Serra do Facão, Goiás state, from May 2008 to September 2013.

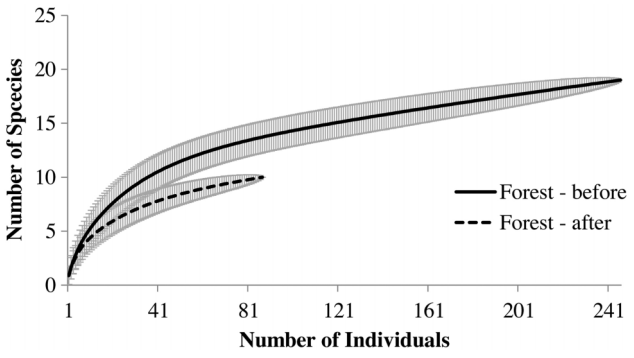

Figure 6. Rarefaction curves for small non-volant mammals in forest enviroments before (May 2008 to November 2009) and after (February 2010 to September 2013) the reservoir flooding of the Hydroeletric Power Plant of Serra do Facão.

with about 132,000 ha (Rodrigues et al. 2002). Águas Emendadas Ecological Station, in the Federal District, with 11,000 ha, shows similar species richness (Marinho-Filho et al. 1998) to Serra do Facão region. Other studies found between 24 and 93 species for areas of different sizes and locations in the Brazilian cerrado (Mares et al. 1989, Schneider 2000, Moreira et al. 2008, Pereira & Geise 2009) (Table 2).

Small Mammals – We recorded 20 species of small non-flying mammals. About 25% of them were exclusive to forest environments and 15% were recorded only in open areas. This pattern is expected for the cerrado biome (Marinho-Filho et al. 2002). Considering studies in Protected Areas of cerrado and those that make use of pitfalls in addition to conventional traps, the richness of small non-flying mammals ranged from 19 to 29 species (Schneider 2000, Marinho-Filho et al. 2002, Pereira & Geise 2009, Carmignotto & Aires 2011, Bonvicino et al. 2012). This richness is similar (or even large) than our study, despite our larger sample effort (Table 2). The region of Serra do Facão has been greatly altered by human activity over the last 300 years, and now is also impacted by the fragmentation and reduction of natural habitats imposed by São Marcos river dams and by the infrastructure projects associated to Serra do Facão Hydroelectric Plant (Chaul 1997). However, the richness observed in the region of Serra do Facão is comparable to some Protected Areas in the cerrado domain, and other cerrado localities. We recorded some cerrado rare species (Marinho-Filho et al. 2002) as *Oecomys cleberi*, *Micoureus demerarae, Caluromys lanatus*, and *Thylamys karimii*, and their records were also rare throughout the study. The higher richness of forests when compared to open areas are also an expected finding for cerrado small non-flying mastofauna (Marinho-Filho et al. 2002).

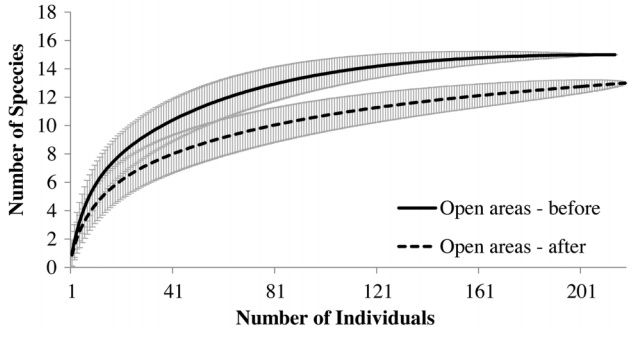

Figure 5. Rarefaction curves for small non-volant mammals in open areas before (May 2008 to November 2009) and after (February 2010 to September 2013) the reservoir flooding of the Hydroeletric Power Plant of Serra do Facão.

The reservoir formation for the hydroelectric enterprise on Serra do Facão seemingly affected the small mammal diversity in open and forest habitats. The impacts of hydroelectric power plants on mammal communities were investigated by several other studies, and species loss is a common effect of reservoir filling (Cosson et al. 1999, Fournier-Chambrillon et al. 2000, Alho 2011, Andriolo et al. 2013). Besides habitat (and area) loss, the increase of predation and competition intensity are possible as factors affecting small non-flying mammals diversity loss in this kind of environmental change (Lemos de Sá 1995, Alho 2011, Andriolo et al. 2013, Passamani & Cerboncini 2013).

Marsupials presented seasonal reproduction, whereas rodents were reproductive year round (Figure 3). The marsupial *Gracilinanus agilis* showed marked seasonal reproduction, confirming previous studies (Mares et al. 1989, Mares & Ernest 1995) but the rodent *Calomys tener*, was reproductive in both rainy and dry seasons (Figure 3). Studies carried out in central cerrado showed that the reproduction in *C. tener* females is significantly greater during the rainy season, with reproductive individuals recorded year round, but in lower proportions during the dry season (Mares et al. 1989, Rocha 2011).

Bats – Bat richness in Serra do Facão is lower when compared to other areas in cerrado, which presented a richness ranging from 16 to 25 species (Marinho-Filho et al. 1998, Aguiar 2000, Rodrigues et al. 2002, Bezerra & Marinho-Filho 2010). We recorded 10 species of bats, which represents only 10% of the richness known to the cerrado (Paglia et al. 2012). Although some other studies report equally modest numbers of bat species found in some cerrado areas (see Table 2 e.g. (Moreira et al. 2008) such low richness seems to be more an effect of relatively small sampling effort. The fact that we also only captured phyllostomid bats is expected with mist nets. The bat community from Serra do Facão is clearly undestimated and more species will be added with further sampling. However, there are some interesting records such as an individual of *Mimon benetti* a gleaning animalivore, not so common in inventories and collections. Although *Anoura caudifer* presents a wide distribution in South America,

Table 2. Mammalian richness from different Cerrado localities, including Protected Areas (PA).

Richness	PA	Methodology	Year	Sampling effort	References
Small non-flying mammals					
18	yes	Sherman/Wire traps	1986-1998	not available	Marinho-Filho et al. 1998
19	yes	Sherman/Wire traps Pitfall	2002-2004	10,897 traps*night 2,671pifalls*night	Pereira & Geise 2009
19	no	Sherman/Wire traps	1998; 1999; 2010	7,651 traps*night	Bonvicino et al. 2012
20	**no**	**Sherman/Wire traps** **Pitfall**	**2008-2013**	**31,496 traps*night** **49,600 pitfalls*night**	**This study**
21	yes	Sherman/Wire traps	1999-2000	13,200 traps*night	Santos-Filho et al. 2012
23	yes	Sherman/Wire traps Pitfall	1998-1999	10,664 traps*night 2,898 traps*night	Carmignotto et al. 2014
24	yes	Sherman/Wire traps Pitfall	1998-1999	10,664 traps*night 2,898 pifalls*night	Rodrigues et al. 2002
24	yes	Sherman/Wire traps Pitfall	2003; 2008	5,396 traps*night 5,300 pifalls*night	Carmignotto & Aires 2011
29	no	Sherman/Wire traps Pitfall	1988-1989; 1998-1999; 1997	not available not available	Schneider 2000
Bats					
9	no	Mist net	2003-2004	2,520 m2*hour	Moreira et al. 2008
10	**no**	**Mist net**	**2008-2013**	**18,144 m2*hour**	**This study**
16	yes	Mist net	1986-1998	not available	Marinho-Filho et al. 1998
17	Both	Mist net	1983-1984	not available	Mares et al. 1989
22	yes	Mist net	1998-1999	388,800 m2*hour	Aguiar 2000
23	no	Mist net	2004	16,650 m2*hour	Bezerra & Marinho-Filho 2010
24	yes	Mist net	1998-1999	26,838 m2*hour	Rodrigues et al. 2002
25	no	Mist net	1997; 1998 - 1999	not available	Schneider 2000
Large mammals					
10	no	Observations	2003-2004	80 hours	Moreira et al. 2008
10	yes	Observations	2002-2004	not available	Pereira & Geise 2009
17	yes	Observations	2003; 2008	not available	Carmignotto & Aires 2011
18	no	Observations	2008-2009	143.51 km - 320 hours	Alves et al. 2014
23	no	Observations	2008-2009	7,200 km	Bocchiglieri et al. 2010
26	yes	Track stations Census	2001-2002	1,518 track stations*night 309 km - 207 hours	Oliveira et al. 2009
29	Both	Observations	1983-1984	not available	Mares et al. 1989
32	yes	Observations	1986-1998	not available	Marinho-Filho et al. 1998
33	**no**	**Observations** **Camera trap**	**2008-2013**	**not available** **14,508 traps.hour**	**This study**
38	no	Observations	1999-2000	not available	Brito et al. 2001
39	no	Observations	1988-1989; 1998-1999; 1997	not available	Schneider 2000
37	yes	Observations/Census	1994-1999	not available	Rodrigues et al. 2002
All mammals					
24	no		2003-2004		Moreira et al. 2008
58	yes		2002-2004		Pereira & Geise 2009
63	**no**		**2008-2013**		**This study**
66	yes		1986-1998		Marinho-Filho et al. 1998
85	yes		1994-1999		Rodrigues et al. 2002
86	Both		1983-1984		Mares et al. 1989
93	no		1997; 1998-1999		Schneider 2000

occurring in several Brazilian states, there are few localities in the Brazilian cerrado with formal records in the literature (Oprea et al. 2009), and the species was recorded only in northeastern Goiás (Zortéa & Alho 2008, Bezerra & Marinho-Filho 2010, Peracchi et al. 2010). The present record of *A. caudifer* indicates this species presents a wider distribution across the cerrado. The small bat species richness verified at Serra do Facão may have been caused by a number of causes as well as their combination. 1) We used only mist nets to sample bats and no bat detectors that help to find and identify species that fly high above the canopy of forests and are not easily captured with nets. 2) Bat sampling was conducted in the period between

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18:00 and 24:00 h, and consequently; 3) not all bat activity periods were covered and not all areas were explored as well as collection did not take place in all field trips. Thus, the assemblage of bats in Serra do Facão is clearly underestimated and further studies remain be done.

Large mammals – We recorded 33 large mammals species (Table 1, Supplement 4), a richness higher than the sum of richness found in three Protected Areas in Brasília (n = 25) (Juarez 2008). Other studies also carried out in other cerrado regions, including Protected Areas (Marinho-Filho et al. 1998, Schneider 2000, Brito et al. 2001, Rodrigues et al. 2002, Moreira et al. 2008, Oliveira et al. 2009, Bocchiglieri et al. 2010, Carmignotto & Aires 2011, Alves et al. 2014), recorded 10 to 39 species of large mammals (Table 2). However, any comparison on large mammal richness between areas is limited because there is not a standard methodology used in different studies and the sampling efforts performed for this group in different studies are also very different. Indeed, most large mammals checklists are based on opportunistic data.

Eigth species of larger mammals surveyed are threatened with extinction (MMA 2014): *Priodontes maximus*, *Mymercophaga tridactyla*, *Chrysocyon brachyurus*, *Lycalopex vetulus, Leopardus tigrinus, L. wiedii*, *Puma concolor,* and *P. yagouaroundi.* The giant armadillo, *Priodontes maximus,* occurs in nearly all Brazilian biomes (Medri et al. 2010). This species, as well as their characteristic burrows, were found in both open and forest areas by direct observation and camera trapping. The fact that this species is considered extinct in various localities of southern Brazil (Marinho-Filho & Medri 2008) and is currently declining in other Brazilian regions, reinforces the importance of Serra do Facão for the conservation of its wild populations. Another threatened species found was the giant anteater, *Mymercophaga tridactyla*, which originally occurred in all Brazilian biomes, but is currently considered extinct in eastern states of Rio de Janeiro and Espírito Santo, and its populations are declining in southern, southeastern and northeastern Brazil (Medri & Mourão 2008). In the present study, the giant anteater was the most frequently recorded species among large mammals, using both open and forest areas - where most records were made.

The maned wolf, *Chrysocyon brachyurus*, a species associated with central Brazilian cerrados (Cheida & Santos 2010) was one of the rarest species in the present study, and the few records were obtained in open vegetation areas. Furthermore, we recorded the occurrence of some felines threatened with extinction. The margay, *Leopardus wiedii*, was spotted only in forest environments. *Puma concolor*, another feline threatened with extinction was the largest predator, with few photo records in the region. We did not detect jaguar, *Panthera onca*, which could explain the considerable abundance of mesopredators, such as *L. wiedii* in the area. The oncilla, *Leopardus tigrinus*, was one of the rarest species among larger mammals and this may be explained by the relatively high frequency of *L. pardalis,* one of the largest predators found, and capable of excluding smaller spotted cats in areas where it is dominant (Oliveira 2004).

Despite the fact that Serra do Facão region has been altered for centuries by several kinds of natural resources exploitation that resulted in a quite fragmented landscape, and the area that we sampled is not included in or near to any protected area, the present study reveals that it still shelters a mammalian fauna corresponding to at least 25% of the total mammalian fauna of the whole cerrado biome. This richness, in addition to the presence of rare and threatened species, reinforces the importance of natural remnants of cerrado for the conservation of regional mammalian fauna. It also calls attention for the importance of enforcing the protection of natural areas that may be affected by many large infrastructure projects.

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